On the Cuesta Topography of the Boso Peninsula, Chiba Prefecture, Japan

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I. GEOMORPHOLOGIC DIVISION OF THE BOSO PENINSULA

The Boso Peninsula consists of five distinct geomorphologic sections each with its own distinctive geologic and geomorphic characteristics. These, enumerated from the south northwards are : (1) the South Awa Hills, (2) the North Awa Mountains, (3) the Kazusa Hills, (4) the Shimosa Plateau, and (5) the Kujukuri Coastal Plain situated in the east of the Kazusa Hills and Shimosa Plateau (Fig. 1).

The South Awa Hills, which consists of folded marine Miocene and Pliocene formations, is a fine dissected hill with narrow and flat topped summits which measure 100 to 200 meters in altitude.

The North Awa Mountains are developed mainly upon the strongly folded and faulted marine Oligocene and Miocene formations and Mesozoic rocks. The topography controlled by the geologic structure shows the features of block mountains. The central axis of the middle Miocene orogeny of the South Kanto Region (Tanzawa Orogeny : Koike, 1957) is situated in this section. The northern mountain range of this section, 200 to 350 meters in altitude, forms the main stream divide of the Boso Peninsula.

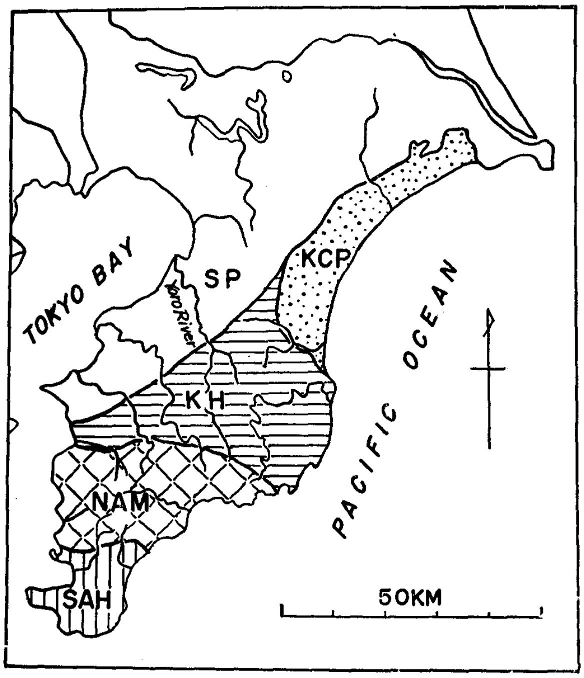

Fig 1. Geomorphologic division of the Boso Peninsula.
SAH : South Awa Hills, NAM : North Awa Mountains, KH : Kazusa Hills, SP : Shimosa Plateau, KCP : Kujukuri Coastal Plain.

The Kazusa Hills are characterized with the alternation of cuestas and valleys. These are developed upon the marine Pliocene and Pleistocene sandstone, conglomerate, and siltstone, which homoclinally dip northwestwards. The cuestas have altitudes of 200 to 350 meters. The back slope of the outermost cuesta (Gongenmori Cuesta), which attains only 160 to 180 meters in

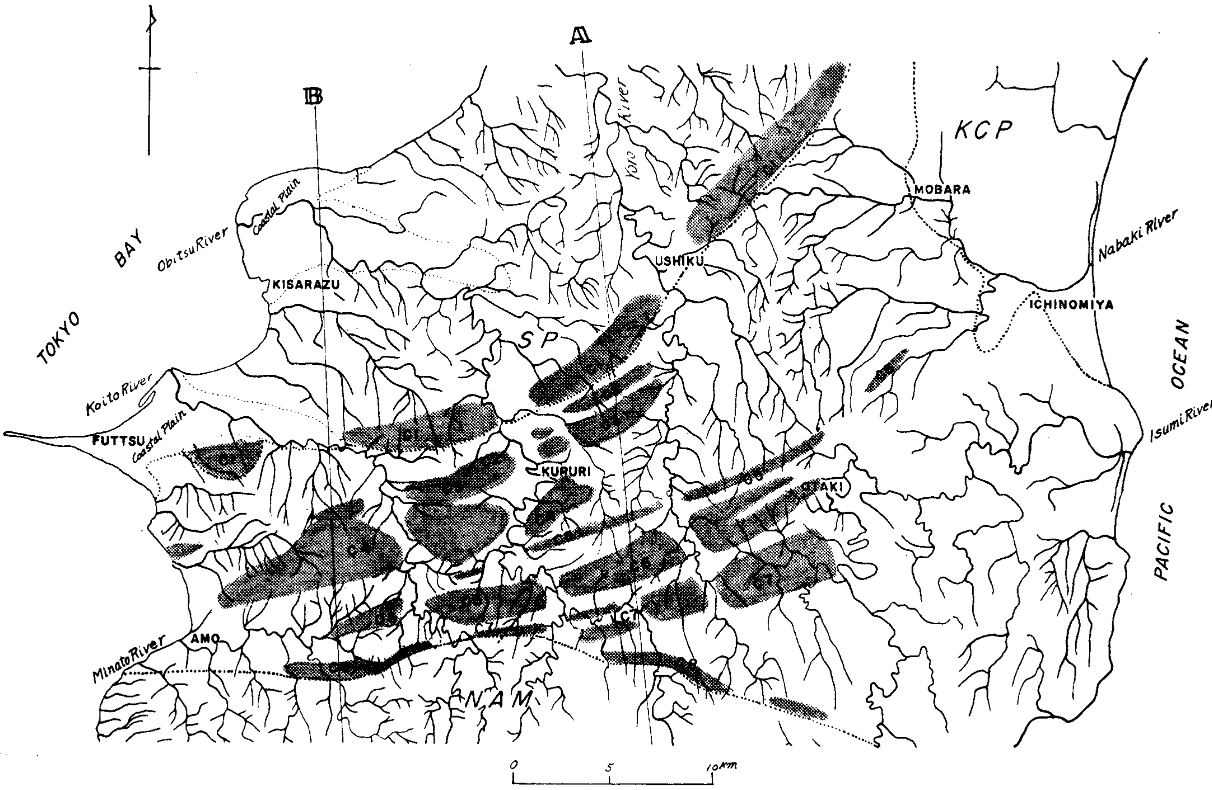

Fig 2a. **Map** showing the distribution of the cadena.

C1 : Gongenmori Cadena
C2 : Sokura Cadena
C3 : Mandano Cadena
C4 : Kanozan Cadena
C5 : Fukuno Cadena
C6 : Daifukuyama Cadena
C7 : Kuratama Cadena (Triple cadena)
C8 : Mitsuishiyama Cadena
SP : Shimosa Plateau
NAM : North Awa Mountains
KCP : Kujukuri Coastal Plain
1 : Conglomerate
2 : Sandstone
3 : Siltstone
4 : Alternation of sandstone and siltstone
5 : Tuff
Narita Group
S : Semata Formation
Y : Yabu Formation
J : Jizodo Formation
Tsurumai Group
Ka : Kasamori Formation
M : Mandano Formation
Ch : Chonan Formation
Akimoto Group
Kk : Kakinokidai Formation
Km : Kokumoto Formation
U : Umegase Formation
Seki Group
O : Otadai Formation
Kw : Kiwada Formation
Kr : Kurotaki Formation
Toyooka Group *T*
———— : Conformity
~~~~~~ : Unconformity

altitude forms the southeastern part of the Shimosa Plateau whose topographic surface is a portion of the Shimosueyoshi Plain. This plain occupies the larger part of the Kanto Plain which averages 35 to 40 meters in altitude.

The Kujukuri Coastal Plain is separated from the Kazusa Hills and the Shimosa Plateau by the escarpment on the west.
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II. TOPOGRAPHY AND PERVIOUS ORIGIN OF THE CUESTA

The cuestas of the Kazusa Hills, which rise several tens or a 100 meters above the lowlands between them, have abrupt escarpments on the up-dip southeast side and more gentle back slopes on the northwest dip side. The stratigraphic position and rock facies of the respective cuesta makers are shown in Fig. 2. The dip of the strata in this section decreases from 15 degrees in the south to 5 degrees in the north.

The main rivers in the northern part of the Boso Peninsula are consequent streams flowing from the northern part of the North Awa Mountains through the Kazusa Hills and across the cuestas. The tributaries flow from the back slopes and escarpments of the cuestas, and subsequently through the lowlands, to join the main rivers.

The drainage texture of the cuestas are much coarser than that of the lowlands (Pl. 40). Where the river crosses the cuesta, no gorge or steep sided valleys are developed but rather gentle and wide shape ones prevail. Steep valleys develope in the lowlands. These features suggest a pervious nature of the sediments making them and the origin of the cuesta.

Cuesta is the common regional expression of gently dipping rocks. Where more easily eroded layers of rock are exposed, downwearing is rapid, resulting in the production of lowlands. Between them rise belts of hills, which are formed of resistant layers. Two types of resistance according to the kind of rocks by which cuesta shaping is governed could be distinguished as follows. They are: (1) direct resistance to downwearing agencies caused by the hardness of the rock, and (2) indirect resistance caused by the permeability of the rock. The examples of the former are the cuestas of eastern England, the Paris Basin, and the Niagara area of North America where oolite, chalk, limestone, and dolomite form the cuestas.

Where the consequent streams cut across the hard rocks making the cuestas, narrow valleys or deep notches with steep walls and hanging falls should be developed. On the contrary, where the consequent streams cut across cuestas formed from permeable layers, the streams may widen the valleys, even though the same rock forms the cuesta ridges.

In a region of moderate precipitation, rain-fall upon the impermeable rock is subjected to flow down the land surface in a concentrated runoff, and this can finely dissect the land. However, in the case of pervious rock, rain-fall can not develope a concentrated runoff, because the permeable rock will absorb the surface water before the transition from the unconcentrated to concentrated runoff. As a result the land will not be finely dissected. Owing to the difference in the rate of dissection of the permeable and impermeable rocks, downwearing should be retarded in the former kind of rocks. This is the pervious origin of cuesta.

This origin is well displayed and favorable in the Kazusa Hills of the Boso Peninsula where the cuestas are formed of loose and permeable sandstone and conglomerate layers. Such lithology do not resist the erosion of the streams with sufficient volumes when they enter the permeable rock zones which they cross to maintain themselves despite losses by seepage. The drainage texture of such cuestas are much coarser than that of siltstone

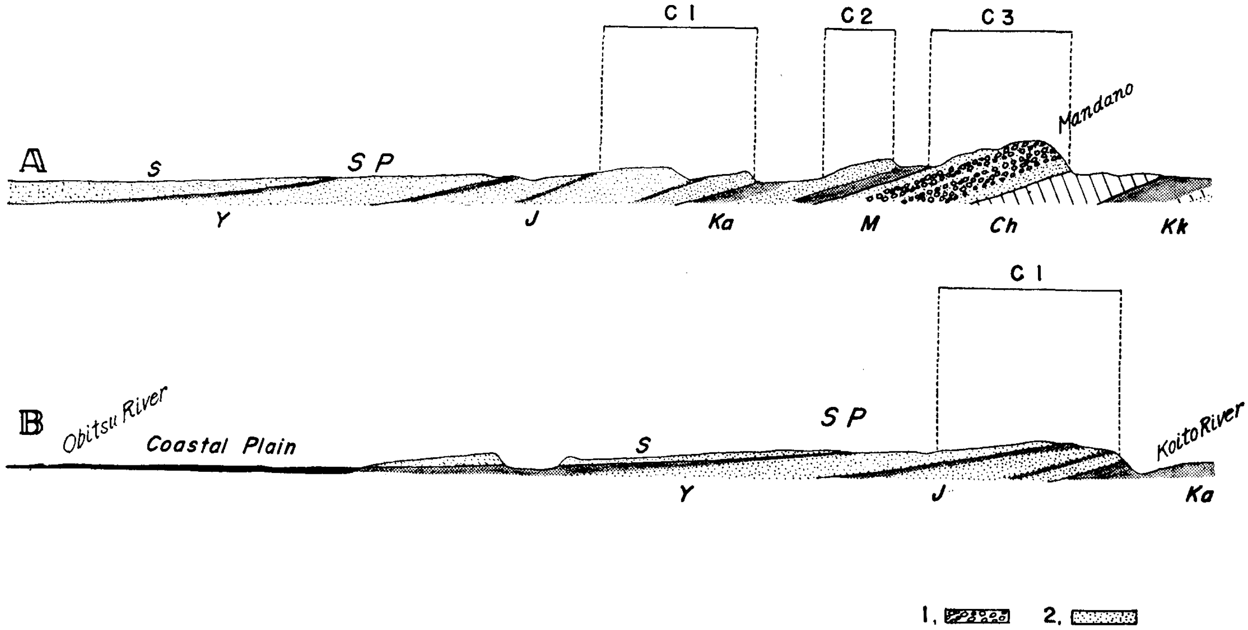


Fig. 2b. Geologic sections showing the

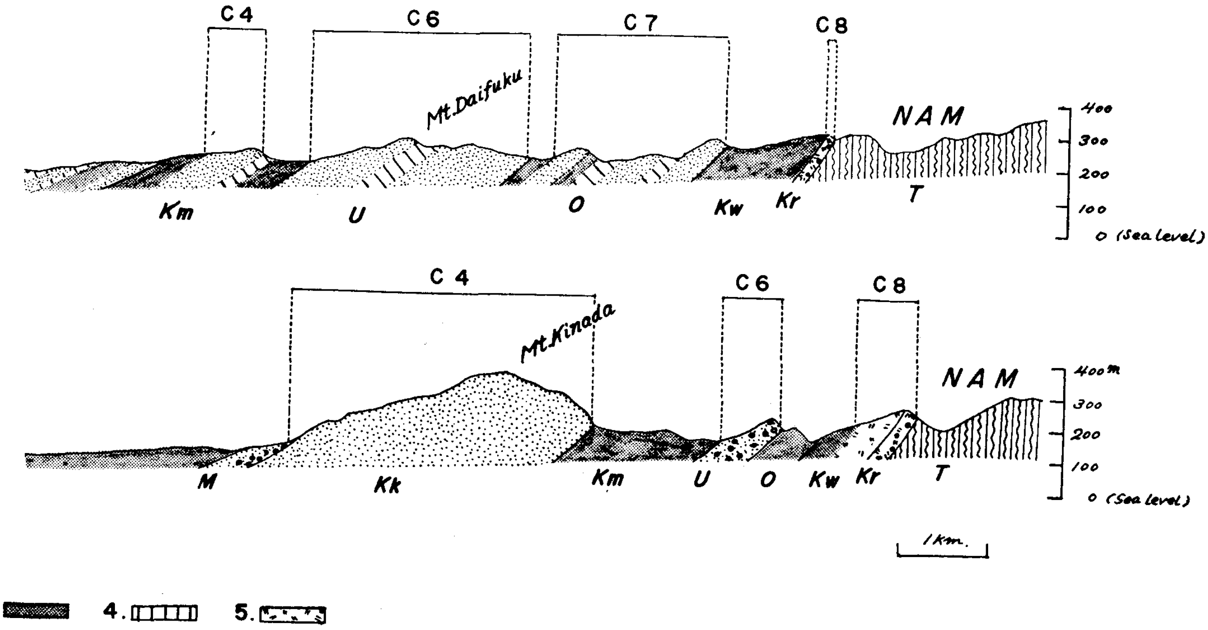
lowlands, and are intermitted by the gentle wide valleys where they meet the consequent main rivers.

This cuesta resembles the pattern of cuesta formed by hard layers in the drainage arrangement of consequent and subsequent tributaries incised in it, but differs from those developed in permeable rocks by the dissected interfluvial ridge having round crest and broad valley through which the main consequent river traverses the cuesta. There are significant differences between the effects resulting from hard and permeable rocks. It is desirable to distinguish the two kinds of cuesta, those formed by the pervious strata may be called by the term *cadena*. By this procedure the term cuesta can be retained for the ones with impermeable hard rock makers.

Davis (1899) designated as cuesta certain longitudinal uplands in recently emerged coastal plain underlain by seaward-dipping resistant but permeable and weak strata. In the same paper, he applied the term cuesta to the hard rock ridges developed in the Mesozoic and Paleozoic coastal plains of eastern England, northern United States, and southern Germany. He thought them to be topographic features shaped through the same process. Martonne (1920) proposed the two-cycle origin of cuestas, because not all of them were developed in seaward-dipping regions and recently emerged coastal plain.

The cuesta originally proposed and used in the earlier pages by Davis is a good example of cadena, and Martonne's cuesta includes both hard and pervious types of cuesta. From the developmental process and relationship with lithology and geological structure, it may be advisable or at least more favourable to restrict the term cuesta to hard rock ridges in a region of homoclinal structure.

For the sake of convenience and to make clear the kind of cuesta being discussed and to avoid confusion as well as unusually lengthy descriptions, the writer heareafter uses the term cadena.



stratigraphic position of the cadena makers.

III. ARRANGEMENT OF THE CADENA AND ITS IMPLICATIONS

Geologic structure and lateral change of the lithofacies of the cadena are the factors controlling the arrangement of the cadenas. Two distinct tendencies in the arrangement of the cadenas are recognized. (1) The cadenas which parallel each other in northeast trend but converge westward, and (2) those that become obscure eastward and disappear in the east of the middle course of the Yoro River (Fig. 2).

The Pliocene and Pleistocene formations including the cadena makers were deposited in a synclinal basin between the Tanzawa-Mineoka orogenic belt and the Kanto Tectonic Line which stretches from Takasaki to Choshi (Fig. 3). This is one of the most important tectonic lines in the geologic structure of the Kanto Region, and is considered to have been the result of the Tanzawa Orogeny which reached its climax during the middle Miocene age.

The Seki group including the Kurotaki, Kiwada, and Otadai formations, which is unconformably underlain by the gently folded uppermost Miocene Toyooka group, rapidly thickens northeastwards with the increase in the distance from the orogenic belt.

The Seki group is overlain by the Akimoto group of the Umegase, Kokumoto, and Kakinokidai formations unconformably in the western part and conformably in the middle and northeastern parts far from the orogenic belt. The siltstones of the Akimoto group are intercalated between the sandstone and conglomerate layers upon approaching the flank of the former orogenic belt.

The Tsurumai group, which includes the Chonan, Mandano, and Kasamori formations, overlies the Akimoto group unconformably in the west, and conformably in the middle and east. Conspicuous cobbly conglomerate and coarse sandstone layers of the Mandano formation, which continue from the west coast of the peninsula to the middle course of the

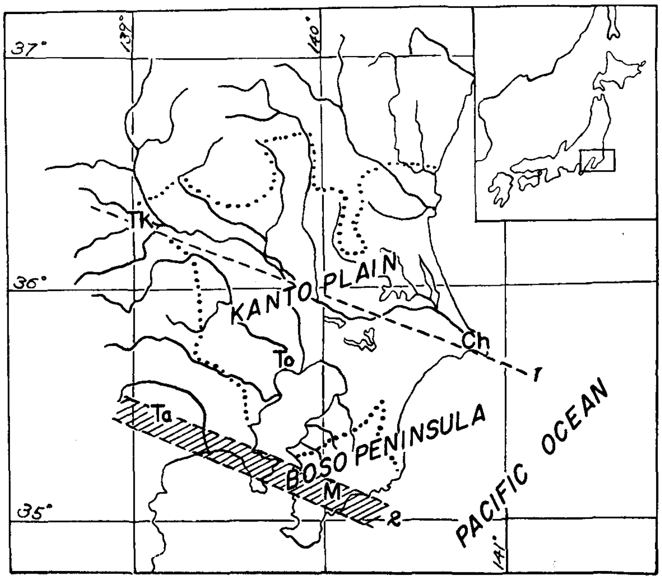


Fig. 3. 1 : Kanto Tectonic Line, 2 : Tanzawa-Mineoka Belt. To : Tokyo, Tk : Takasaki, Ch : Choshi, Ta : Mt. Tanzawa, M : Mt. Mineoka.

Yoro River, diverge into thin sandstone layers near the Yoro River, and thence rapidly disappear in the siltstone of the Kasamori formation.

The Narita, which is the youngest marine Pleistocene group in the Kanto Region, exhibits a somewhat different attitude from the former groups. This group does not conspicuously change in its facies and thickness laterally, but is widely distributed over the Kanto Plain region with no influence or restriction of the Tanzawa-Mineoka orogenic belt and the Kanto Tectonic Line. The Narita group changes in its lithofacies vertically rather than laterally, and the cyclic vertical change in its sedimentary facies is thought to be a reflection of the Pleistocene glacial eustatic change of sea-level and the associated climatic change (Nakagawa, 1960).

The central area of deposition of these groups has successively migrated northwestwards with the up-tilting of the region southeastwards during deposition in the synclinal basin between the Tanzawa-Mineoka belt and the Kanto Tectonic Line. For such reasons the layers now overlappingly one another converge westwards and homoclinally dip northwestwards. The present strike of the respective layers is at right angles to the axial trend of the Tanzawa-Mineoka belt and the Kanto Tectonic Line in the central part of distribution, while it is subparallel with the same trend in the zone around the Tanzawa-Mineoka belt.

IV. CONCLUSION

The cadena topography of the Boso Peninsula may be formed in the alternation of sandstone, conglomerate, and siltstone by their differential pervious characters which are intimately related to the fine dissection and downwearing of the land. There are mutual relations between the tendencies of change in thickness, rock facies, and present strike of layers. The arrangement of the cadenas which are formed by the coarse grained layered rocks represents and reflects the post-Tanzawa Orogenic history of the structural and sedimentary growth of the northern Boso Peninsula.

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EXPLANATION TO PLATE 40

Air photograph showing drainage patterns and texture of the Kanozan Cadena and the lowlands bordering it. There is a strong impression that the drainage texture is closely related with the lithofacies of the cadena and the lowlands, and that the cadena differs from the hard rock cuesta by the broad valley traversed by the main consequent river. (Reproduced by permission of the Geographical Survey of Japan.)


0 1 2 3 4 5 KM